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Treatment of Peat Water Using Local Raw Material Formulations of Jambi, Indonesia

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The parameters such as colour, pH, iron, TDS and organic matter are the indicater of water quality and these can be improved using specific treatment. In present study, clean chemically bentone (CCBN) a local raw material was used to process peat water. The ISO and ASTM, UV-visible and AAS standard methods were used to measure the respective parameters. Bentonite, active carbon, seashells and clean chemically bentone were characterized by X-ray diffraction and SEM-EDS. By supporting bentonite on material clean chemically bentone was prepared, total 61 combination was prepared and four best formulations were CCBNBT56'5'1, CCBNBB56'5'1, CCBNBCs5651 and CCBNBP5651 used for peat water treatment. These best formulations showed good ability to improve the peat water quality and dose of 1 g/500 mL increased the pH up to 7. As a result of treatment, the peat colour reduced up to 93.99 %, whereas 86.69 % organic matter and 89.47 %. Fe concents were reduced using CCBN56'5'1 formulation. The composition of formulation was kaolinite mineral [$Al_2Si_2O_5(OH)_2$], quarsa (SiO_2), montmorillonite $(OH)_4Si_8Al_4O_{20}\cdot nH_2O$, cristobalite ($SiO_2$), portlandite [$Ca(OH)_2$], calcit ($CaCO_3$) and muscovite ($KNaAl_2(SiAl)_4O_{10}(OH)_2$, with an average specific gravity (density 2.5245 g cm^{-3} and μ/dx mix 52.8 cm^2 g^{-1}). From results, it can be concluded that the material prepared from bentonite can be used for the removal of colour, organic matter and Fe contents of peat water.

Keywords: Water peat, Bentonite, Active carbon, Shell, CCBN5651.

INTRODUCTION

Demand for clean water in the world is continuesely increasing[1]. Indonesia is spending almost four trillion dollars per year to meet the shortage of clean water since 2000 to date under the agreement of the millennium development goals (MDGs) and the UN general assembly. According to Central Bureau of Statistics, the Indonesia population is 247.5 million[2]. It needs 9391 billion m^3 which is 47 % higher as comparsion to 2000[3] and situation will be more verson in coming decades[1]. On the other hand, in Indonesia there are still many obstacles to meet the clean waster, especially in coastal areas. Indonesia is a maritime country having land area of 1.9 million km^2 and 5.8 million km^2 is ocean[4]. Therefore, Indonesia will be one of the countries that will experience a water crisis in coming decades[3].

Clean water crisis always occurs in Sumatra and Kalimantan, especially in the dry season and resultantly, river water supply reduced and well turns dry and available water became acidic, brownish and contains organic in high concentration and consumer avoid to use this water. Water quality in the lowlands is influenced by topography and rainfall[5]. Rainfall in the area is relatively high and in Jambi average range is 179-279 mm^2. Therefore, water turns dark brown to black (peat) with TDS content of 60-120 mg/L, colour 124-850 mg/L PtCo, organic matter 138-1560 mg/L and pH of 3.7 to 5.3[5]. Widayat and Said[6] reported 5.2 pH, 1.623 mg/L Fe and 20.67 mg/L Cu in the Siak river water, whereas the peat water in Borneo Siantan River revealed the colour 624 mg/L PtCo[7]. Various researchers reported that the peat water quality from Jambi and found that water quality is badly affected and needs some treatment before domestic purposes[8-12]. It is also reported that the organic contents in peat water converted into complex structures by combining with -COOH and OH^-, phenolics and became non-biodegradable and resultantly, the peat water biodegradation is very difficult. So, there is need to use some physical, chemical[12,13] and biological treatment reduces humic substances in peat water[14,15].

Several methods have been tried to treat peat water *i.e.*, use of poly aluminium chloride (PAC) for colour reduction in Siantan Hulu Pontianak city and 110 mg/L poly aluminium chloride reduced the colour of peat water 624 to 15 mg/L PtCo[7]. Another method coagulation[5] reduced the turbidity up to 97.18 %

along with 98.2 % colour reduction. Rochayati *et al.*[16] used combined Upflow Anaerobic Filter (UAF) and Slow Sand Filter (SSF) method and resultantly, the peat water colour reduced 804 mg/L PtCo to 118.04 mg/L PtCo. Similarly, Said[17] utilized Mechanical Aeration and Mixing Pump Filter (model TP2AS) in the area Pangkoh Central Kalimantan and turbidity reduced from 10 to 1.58 mg/L, colour from 500 to 10.0 mg/L PtCo, Fe 0.4 to 0.18 mg/L.

It is reported that bentonite has ability to reduced metal concentration form water and previous research shows that bentonite combined with limestone can reduce water colour of peat from 276.34 mg/L PtCo be 0.486 mg/L PtCo and also neutralized the treated water[11]. Therefore, it is of interest to investigate this material for paet water treatment. The clean chemically bentone formulations were prepared using bentonite and coal, alumina and powder shells (*A.granosa* L) and employed for peat water treatment. The treatment effect was evaluated on the basis of colour reduction, pH, Fe and TDS.

EXPERIMENTAL

The pilot project was carried out in the village Bramitan New Tangkit, Jambi Province, Indonesia. Total 30 sample of peat water were collected from three regions, Lowlands scattered in Jambi, Indonesia and quality parameters were measured according to the Indonesian National Standard (SNI) procedure. X-Ray diffraction (XRD), SEM-EDS and AAS were used for characterization. Bentonite was prepared by drying the respective ingredients and heating at 110 ºC and then, 6 % HCl was added. Active carbon prepared from coconut shell, palm oil shells and coal by pyrolysis by heating at 800 ºC and activated with HCl and H_3PO_4. Specification tests conducted were methylene blue absorption, iodine number, ash and volatile substances.

The clean chemically bentone formulations were prepared by combining raw materials in varying ratios and then, selected formulations were tested for peat water cleaning. ANOVA test was performed to test the significance of treatments. Best clean chemically bentone formulation was characterized using X-ray diffraction and SEM-EDS and employed for peat water treatment and effect was evaluated on the basis of colour, TDS, pH, Fe, organic substances, Cu, Cd, Pb, As and Hg. The *E. coli* and *Fecal coli* were also evaluated to test the biological efficacy of treatments. The instrument such as SNI pH meter, UV-visible and AAS were used to measure the respective parameter.

RESULTS AND DISCUSSION

The CCBN formulation prepared by mixing the main raw materials and other additive, were 20 formulations. Among them 10 formulations were prepared from activated bentonite and 10 with non-activated bentonite. All prepared formulations were employed to treate peat water. Results showed that formulations prepared from non-activated bentonite with CCBN4512 and CCBN5651 were best in treating peat water, whereas activated bentonite prepared with CCBN4521 from Biku Tanjung and Pauh also showed good efficiency (Fig. 1). The difference between the value of prepared formulation, CCBN4512 and CCBN5651 with very thin, but cost effective and also time consuming and can be commercialized. Therefore, formulation prepared from non acvtivated bentonite were used and recommended.

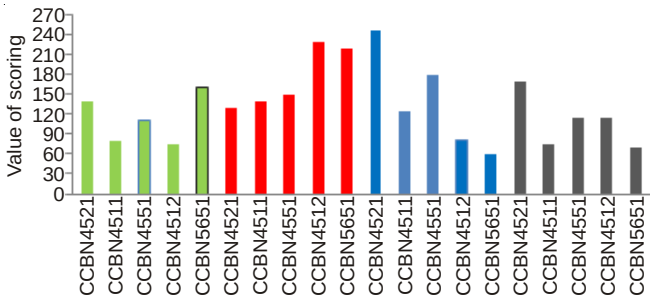

Fig. 1. Scoring effectivity of formula CCBN

The data is almost same for CCBN5651 and CCBN4512 formulation. The statistical analysis showed the effect of both formulations was insignificantly different ($\lambda = 0.05$ and 1.281), thus the ability of CCBN4512 and CCBN5651 to treat peat water was relatively similar. Ability of CCBN5651 formulation in peat water treatment to convert into clean made from nine process variables of different raw materials by using the CCBN5651 formulation and each of the variables used CCBN5651 2 g/L to 10 g/L peat water. From the experimental results, it is clear that the ability of CCBN5651 was excellent in processing peat water. Dose of 2 g/L for all variables showed considerable increase of pH value peat water, from 3.62 to 7.32 and colour was reduced up to 93.99 % colour, organic matter 89.47 % and Fe 86.69 %. These results revaled that the formulations 9 *i.e.*, CCBN5651 was good among all the tested formulations (Fig. 2).

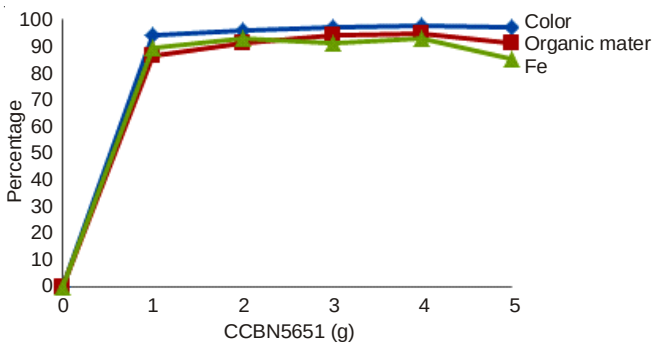

Fig. 2. Discoloration, organic matter and iron in the peat water after addition of formula CCBN5651

It is reported that the coagulation between colloidal particles of CCBN and alumina particles ($Al_2SO_4 \cdot 18H_2O$) occurred which is converted to $Al(OH)_3$ and resultantly, precipited. Floc-floc is formed formed quickly on stirring for 1-2 min followed by 15-20 min[8]. Coagulation and flocculation is closely related to the destabilization of negatively charged particles by the positive charge of the coagulant, the collision of particles and adsorption. Collisions between the particles forming makroflok terdestabilisasi which then undergoes coagulation. Activated carbon to adsorb heavy metals and function of organic substances in peat water can also increase the number of particles dissolved in water peat, these particles destabilized the colloids easly and form a coagulant and given below[8,18]:

$$Al_2(SO_4)_3 \longrightarrow 2Al^{+3} + 3(SO_4)^{2-}$$
$$6H_2O \longrightarrow 6H^+ + 6OH^-$$
$$2Al^{+3} + 6OH^- \longrightarrow 2Al(OH)_3,$$
$$Al_2(SO_4)_3 + 6H_2O^- \rightleftharpoons 2Al(OH)_3 + 6H^+ + 3SO_4^{2-}$$

In this reaction, H^+ released and pH of the solution decreased and flocculation process can not take place perfectly and thefore, due to the formation of $Al(OH)_3$, the pH increased 6 to 8. The addition of calcite powder derived from the shells and alumina sulfate along with $Al(OH)_3$ are produced as shown below[8,18].

$$Al_2(SO_4)_3 + 3Ca(HCO_3)_2 \longrightarrow 2Al(OH)_3 + 3CaSO_4 + 3CO$$
$$Al_2(SO_4)_3 + 3Na_2CO_3 + 3H_2O \longrightarrow 2Al(OH)_3 + 3Na_2SO_4 + 5CO$$
$$Al_2(SO_4)_3 + 3Ca(OH)_2 \longrightarrow 2Al(OH)_3 + 3CaSO_4$$

The principle of peat water acidity reduction reaction by the addition of calcium shells can be explained from the above reaction. One molecule of $Al_2(SO_4)_3$ reacts with three molecules of $Ca(OH)_2$ and resultantly, two molecules of $Al(OH)_3$ produced along with three molecules of $CaSO_4$. Therefore, $Al(OH)_3$ is alkaline in nature and acidic peat water neutralized, pH < 7 $Al(OH)_2^+$, $Al(OH)_2^+$, $Al_2(OH)_2^{4+}$ species are dominant and if, pH > 7 $Al(OH)^{4-}$ and floc-floc $Al(OH)_3$ are formed and coagulation of colloids took place. Sutapa[19] explained that colloidal particles became stable if small and tiny particles settle in a short time. These particles can not merge or joined to each other and are responsible of non conductance another on the surface. Stability of the colloidal suspension caused by the attractive forces between the particles, known as van der Waal forces[20].

The CCBN formulation contains bentonite fine particles, dissolved in water and converted in to colloidal particles of peat and charge on the surface also produced, which leads to stabilization of the suspension. With the addition of some chemicals such as portlandit and calcite, the surface of the colloidal particles can be converted into larger molecules and can be deposited which therefore facilitate the separation of solids by gravity or filtration. Conversion of stable colloidal dispersions due to destabilization and destabilization cause coagulation and flocculation. Often the term coagulation and flocculation are used synonymously, though there are subtle differences between the two if the destabilization induced by charge neutralization by adding some inorganic chemicals and this process is called coagulation. On the other hand, the process in which larger clumps of particles or small agglomerates suspension are formed as a result of coagulation through a high molecular weight polymer material called flocculation. There is no substantial change of surface charge formation during flocculation. Agglomerates formed by coagulation compact and loosely bound, while floks is a larger size, so bound and fragile in the event of flocculation[21].

The mechanism of coagulation-flocculation process depends on several factors, *i.e.*, initial turbidity, pH, reagent (coagulant, adjuvant), dose and type of coagulant[21]. Aluminum sulfate is commonly used as a coagulant agent in water treatment since is it cost effective, efficient, low dose, low toxicity and availability. In the peat water treatment process using CCBN formulation, flocculation process can also aided by the addition of aluminum sulfate with the aim to accelerate the floc formation of colloidal suspensions of inorganic (clay) and organic (humic compounds and fulfat)

Characterization formula CCBN5651 with X-ray diffraction: Based on X-ray diffraction spectra, it was found that CCBN5651 formulation with bentonite raw material from Biku Tanjung has Kaolinite mineral content ($Al_2Si_2O_5(OH)_2$), quarsa (SiO_2), montmorillonite [$(OH)_4Si_8Al_4O_2 \cdot nH_2O$], cristobalite ($SiO_2$), portlandite ($Ca(OH)_2$), calcit ($CaCO_3$) and muscovite ($K, NaAl_2(Si,Al)_4O_{10}(OH)_2$, with an average specific gravity of 2.5245 g cm^{-3} and μ/dx 52.8 cm^2 g mix^{-1} (Fig. 3). SEM-EDS spectra showed that CCBNpk CCBNPkBB and Cs formulation was obtained and composition can be seen in Table-1. The CCBN5651 formulation with coal activated carbon supported that material has higher carbon content as compared to CCBN5651 formulation having palm shell activated carbon and coconut shell supporting material. Al_2O_3 and SiO_2 were recorded higher in CCBN5651 formulation, namely 43.01 % bentonite Pauh and 69.08 % silicate compounds.

Characterizaion of formula CCBN5651 with SEM-EDS: The scanning electron microscopy (SEM) and enery dispertive spectroscopy (EDS) results showed that the CCBN5651 formulation has fine pore structure of activated carbon that might be due to mixing of bentonite and other substances (Fig. 4). Based on the SEM images (Fig. 4), it can be seen that the surface structure of the CCBN5651 formulation was smooth and porous. In CCBN5651 formulation having activated carbon coal, the pores did not diminish and are visible. This might be due to the coal activated carbon pore which was activated with H_3PO_4 because when it was mixed with other materials, the pore remained unchanged and visible. However, it was different in case of CCBN where palm shell activated carbon and coconut shell was used. CCBN5651 formulation found better in lowering the peat water parameters. It is very clear that colour, Fe and organic matter reduced up to 100 %. In addition, the pH also increased of treated peat 6.8 which revealed that peat water was completely neutralized. Thus, the processed water meets the water quality standards implemented by Ministry of Health Minister of Health RI No. 416PER/X/1990.

TABLE-1
RESULTS OF THE ANALYSIS BY X-RAY DIFFRACTIONT SOME FORMULAS CCBN5651

Formula CCBN5651	Composition						Density (g cm^{-3})	μ/dx mix (cm^2 g^{-1})
	Kaolinite	Quartz	Monmorillonite	Cristobalite	Porlandit	Calcit		
CCBNBT5651	5.2	1.5	53.2	10.4	2.9	9.4	2.338	85.2
CCBNBP5651	51.9	7.4	14.9	–	5.4	20.4	2.533	32.0
CCBNpkBB5651	10.0	36.2	11.2	7.5	2.2	8.7	2.619	55.5
CCBNpkCS5651	9.6	28.0	11.6	11.6	3.0	9.6	2.608	58.5

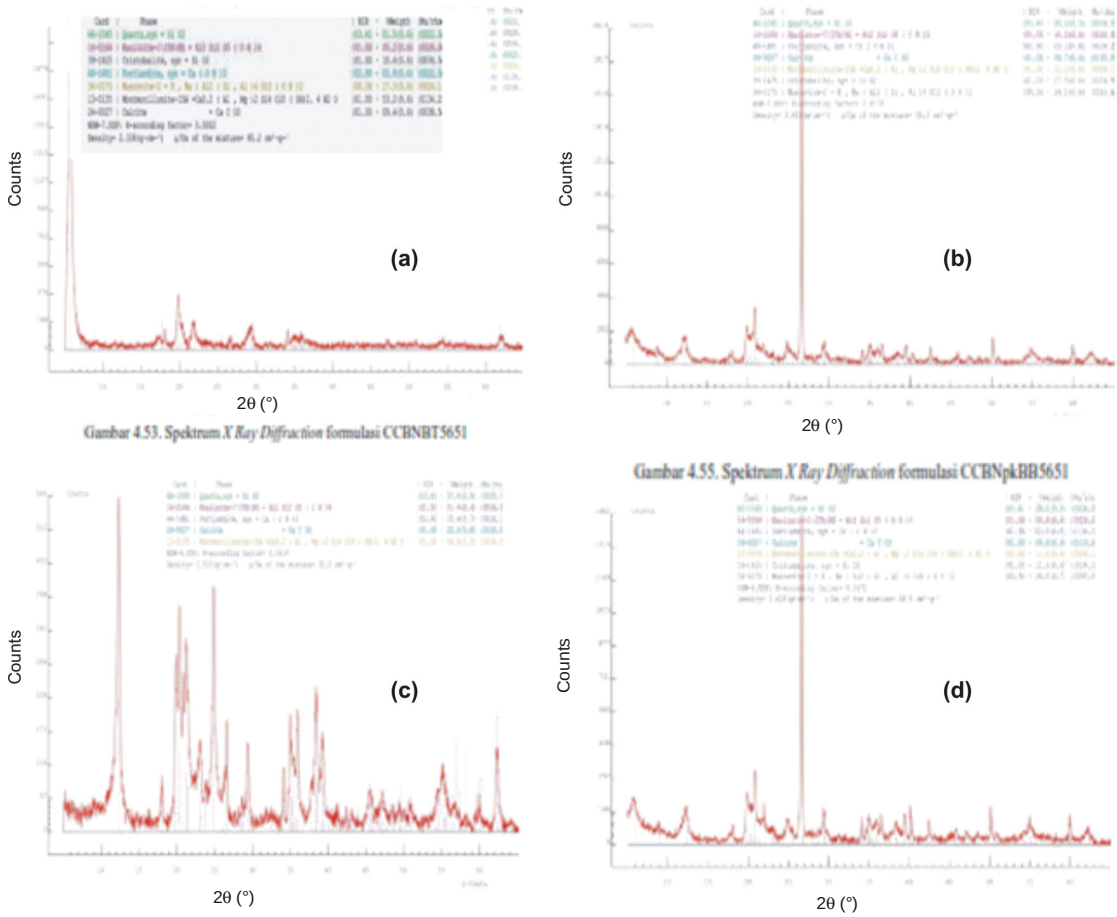

Fig. 3. (a) Spectrum XRD formula CCBNBT5651, (b) Spectrum XRD formula CCBNBPBB5651, (c) Spectrum XRD formula CCBNBPkCs5651, (d) spectrum XRD Formula CCBNBPkCs5651

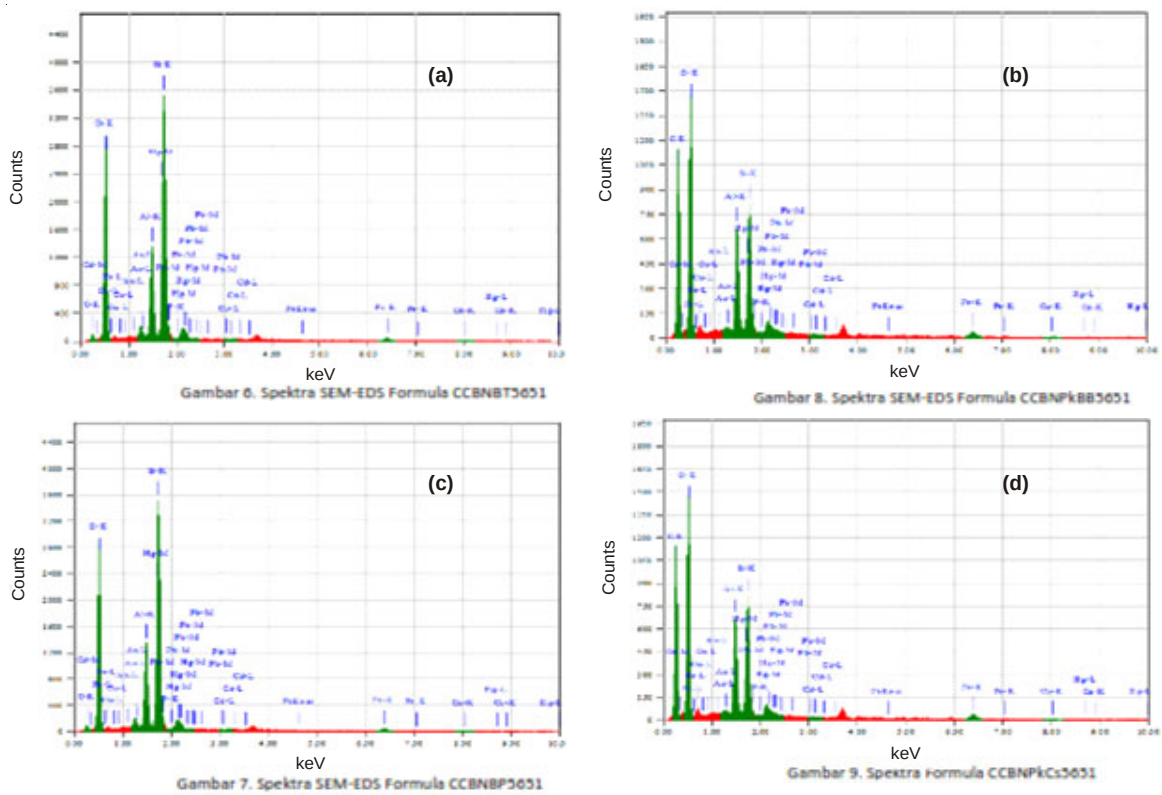

Fig. 4. (a) Spectra SEM-EDS formula CCBNBP5651, (b) Spectrum XRD formula CCBNBPkCs5651, (c) Spectrum XRD formula CCBNBB651, (d) Spectrum XRD formula CCBNBPkCs5651

It was observed that CCBN5651 formulation ability was considerably affected due to kaolinite content, quartz and montmorillonite of bentonite supported by mineral portlandite haing Biku 1.9 % and 5.4 % of the Cape and for bentonite Pauh, minerals calcit by 9.4 % using bentonite Biku Cape and 20.4 % for bentonite Pauh and also an increase in density of 2.21 g cm^{-3} to 3.106 g cm^{-3} bentonite Biku Tanjung and bentonite Pauh density increased from 2.08 to 2.53 g cm^{-3} after formulations. Surface of CCBN5651 formulaton also grew up from 25.0 cm^{-2} g^{-1} to 85.2 cm^{-2} g^{-1} bentonite Biku Tanjung and 22.4 to 32.0 cm^{-2} g^{-1} after formulation. This can be explained that by increasing the density and surface area CCBN5651, the ability to adsorb water material in peat enhanced and formation process of flocculation, coagulation and sedimentation became fast. This might be due to raw materials synergy and compatibility with each other.

The absorption of organic substances and heavy metals in the water occur simultaneously by bentonite and activated carbon, whereas compounds portlandit calcit serves to raise pH of the peat water and also assisted the process of flocculation and coagulation of colloids. It is reported that the activated carbon molecule is non-polar and has lower solubility in water, so that the active carbon can absorb molecules that are non-polar in nature[22]. Activated carbon absorption ability is also influenced by the pores and surface area of activated carbon[23,24].

The water quality results, treated by CCB5651 formulation improved significantly. The processed water was odorless, tasteless pH > 7.00 (neutral), Fe content also reduced (< 0.08 mg L^{-1}) and low organic content were observed. Mirobiol test analysis of processed water with CCBN showed that treatment has good efficiency regarding microbes elimination and coliform decreased from 1700 MPN 100 mL^{-1} to 5 MPN mL^{-1} and colitinja reduced from 110 MPN mL^{-1} to 2 MPN mL^{-1}. From the results of this study, it is clear that the peat water processed using CCBN5651 formulation is feasible for public consumption. This remarkably ability of CCBN5651 formulation is due to all the components of the formulation worked synergistically and effectively. Compounds of calcium oxide and calcite contained in the CCBN5651 function as acid neutralizing agent because pH increased pH > 4.5 to 7.82 and all heavy metals (Fe, Cu, Pb and Mn) were below the permissible limts. Results revealed that using material under investigation, the peat water can be cleaned, however, combination of treatement should be appropriate[6]. Actually, in this process of neutralization can be achieved by mixing lime/limestone along with aeration by pumping air and subsequently, coagulation and filtration is accured, then the peat water treatment with a combination of poly aliminium chloride followed by filtration is able to produce clean water[7]. For microbe elimination, heating (boiling), ultraviolet light, chemical such as chlorine, bromine, iodine (killed virus), potassium permanganate, ozone, silver ions are very effective to kill pathogenic bacteria causing typoid, cholera and dysentery. copper ions are used to remove algae[8].

Conclusion

In present investigation, peat water was treated by localy prepared formulations from bentonine and activated carbons. Bentonite was composed of kaolinite, quartz, montmorillonite and cristobalite and activated carbon was obtained from palm shell, coconut shell. The material was activated by heating at temperatures > 800 °C to form compounds calcite (CaO) and portlanditee [$Ca(OH)_2$] and these prepared materials was used to prepare different formulations and used for peat water treatment. Dose of 2 g/L of CCBN5651 formulation reduced colour, organic matter and Fe up to 93.99, 86.69 and 89.47 %, respectively. Based on present observations, it was found that to prepare effective formulation, characterize raw materials as well as water is needed because different characteristics require different treatment. In present study, CCBN5651 formulation showed promising results and can be employed water treatment followed in combination with reverse osmosis membrane technology, the biofilter, aeration system or ultrafiltration membranes to remove organic matter and TDS.

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